AD-A033 245 DUMONT ELECTRON TUBES CLIFTON N J F/G 9/1
STUDY AND IMPROVEMENT OF THE S-1 PHOTOEMISSIVE SURFACE.(U)
JAN 67 DA-44-009-AMC-1811(E)
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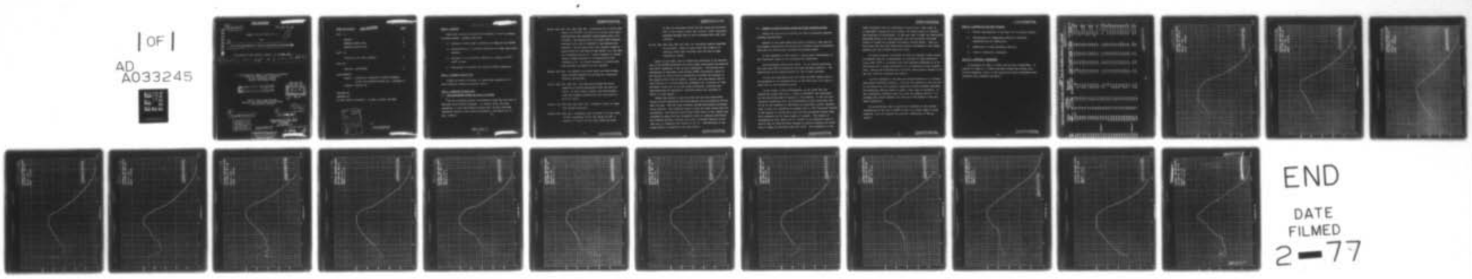

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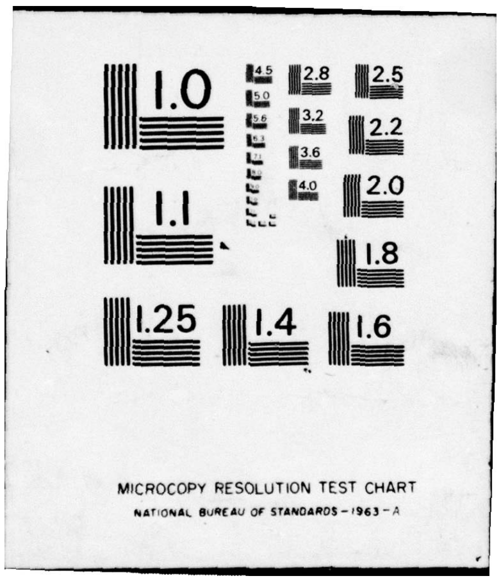
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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

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(14) ETC-334-67

COPY 21 OF 23

~~FIRST~~ QUARTERLY REPORT NO. 3 (1)

B S.

FOR

(6) STUDY AND IMPROVEMENT OF THE S-1 PHOTOEMISSIVE SURFACE. ~~(U)~~

THIS REPORT COVERS PERIOD 1 AUGUST - 31 OCTOBER 1966

(9) Quarterly (1st) rept. no. 3, 1 Aug-31 Oct 66.

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CAMERA AND INSTRUMENT CORPORATION
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CLIFTON, NEW JERSEY 07015

UNITED STATES ARMY ENGINEER
RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

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(11) 16 Jan 1967

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DU MONT CONTROL DOCUMENTS: SI-6384, T6-2018, MO-10198

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PART I - PURPOSE

Under this contract, photoelectric emission of the S-1 surface is being studied. Specific aims are:

1. Increase of white light sensitivity to 100 μa/l for 2870°K.

2. Reproducibility of processing schedules for high sensitivity cathodes.

3. Lowering of the thermionic emission to a value of 10^{-13} A/cm^2 or less.

4. Measurement of physical and optical surface properties.

PART I - GENERAL FACTUAL DATA

During the month of October, 25 tubes were assembled, 22 of which attained cathode processing status.

PART I - DETAILED FACTUAL DATA

A. Tube processing during the month of October

The new processing methods investigated during the last half of September were further developed. In several tubes, the same properties of very high infrared sensitivity, coupled with high thermionic emission, were again experienced. (See Report No. 2, pgs. 3 and 4).

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In Nos. 037, 047, 049, 051, 055, 056 - essentially one Cs drift with bakeup to 100-140°C (variable) gave medium white light sensitivities with infrared sensitivities from 7.0 to 9.0 µa/l. The sensitivity of 10.0 µa/l 2540 response, measured on No. 056 on 10/31/66 is the highest ever reported. In all these tubes, the surfaces showed no deterioration on the bake-cooling cycle; i.e., the bake was terminated only if a) further increase in leakage without further increase in photosensitivity was observed, or b) no further decrease in conductivity with increase in temperature was observed.

In Nos. 037, 049 - an attempt to re-treat after the bake-cooling cycle actually lowered the sensitivity, especially infrared sensitivity.

In Nos. 036, 042, 050, 057 - the bake cycle caused the photosensitivity to drop drastically after the first Cs drift. In these cases, however, the bake-cooling cycle was applied successfully after the second or third Cs drift.

In Nos. 033, 038, 040, 041, 043, 044 - attempts to dope for lower dark current were made.

In Nos. 033, 040, 044 - prewetting with K instead of Cs was tried; in 041, prewetting with Rb was tried; in 038, a mixture of K and Cs in the first drift was used;

on 043, Bi evaporated before the bake cycle was performed. None of the effects sought were evident; either thermionic emission remained high or poor processing (Nos. 038, 043) resulted.

In Nos. 034, 035, 039, 052, 053, 054 - no reasonable cathode formation was possible. Three of these tubes were found to be leakers; three never recovered from the drop on high temperature baking.

Again, on all tubes, the Ag laydown was controlled by the measurement of the 8975Å transmission and white light transmission was measured only after completion of the Ag base preparation. Difficulties were encountered in achieving a well-defined 8975Å transmission figure as the red glow of the Ag bead on evaporation disturbed the response of the pickup device (one S-1 diode). However, the measurement will be made standard as it practically has eliminated the occurrence of "bad Ag-layers" which are, as we have noted previously, connected with abnormally high IR absorption. Detailed results are contained in Table I of this report.

During this period it was found that the absolute sensitivity figures in mA/W determined from measurements with monochromatic filters were too high. This was then confirmed through measurements performed at Ft. Belvoir. The suspected reason is that the light source went off calibration. The absolute sensitivity values given in this report were corrected to agree with the integration value of luminous sensitivity and relative spectral response curve over a standard tungsten source (see e.g., R. Engstrom, RCA Review 21, No. 2). Recalibration of the energy values is planned for the next period.

B. Summary of work performed during the first quarterly period

During this period good progress was made in achieving improved infrared sensitivities.

Because of the great importance which we assess to this part of the program, practically all activity was directed toward experimentation with one particularly successful processing method.

In the beginning of this period, a long overdue investigation of the "classical" method of S-1 formation was undertaken.

The anticipated results were found: low to medium sensitivity with more than 10% IR sensitivity and high thermionic emission. The sensitivity did not exceed 40 μa/l for any of these surfaces.

It was also established that the older "Du Mont" method used in the beginning of our research effort on AMC 136-T was, so to speak, a limit case of the classical cathode.

In the course of this investigation, it was found that one particular process step (i.e., a bake to 100-140°C) was responsible for the relatively high IR response of the cathode. It was also conclusively established that the effectiveness of this processing step is not at all dependent on additional Ag evaporation, which, incidentally, so far, was considered an integral part of the "classical" method. It was logical to combine this step with the processing methods found most successful in the later stages of contract. This method of processing was also called for as a result of our empirical model of the S-1 and our theories about shaping of spectral response and avoidance of slump, as developed under AMC 136-T. The combination of the

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"fast Cs-method" with low temperature Cs drift plus a bake cycle up to 100-135°C, followed by slow cooling, did indeed result in cathodes with excellent IR sensitivity. At the same time, "slump" was practically eliminated which is in full agreement with the previously developed theory of "slump" as Cs drifts into deeper cathode layers. Thus, it would seem that the high temperature achieves saturation of the entire cathode layer and prevents long term drift.

It should, however, be pointed out that an analogous effect cannot be achieved when the Cs interaction is performed at high temperature (i.e., above 80°C). It appears that more favorable adherence of Cs to the Ag base and a larger absorption of Cs is achieved at lower temperature. Through the following heat treatment, these greater amounts of Cs are then diffused throughout the cathode.

A serious drawback of the high sensitivity achieved is a considerably higher thermionic emission. Although the reasons for this are not at all understood, the empirical connection between extended threshold and thermionic emission seems to apply to this type of formation. So far, suppression treatments have not shown encouraging results. All attempts have either impaired the efficacy of the method or have not shown suppression.

As an additional step to control the condition of the Ag base, transmission of the base to 8975Å as well as to white light is being measured. This has resulted in practical elimination of "bad Ag layers".

PART II - PROGRAM FOR THE NEXT INTERVAL

1. Further investigation of the high "IR" processing methods.

2. Investigation of temperature effects on substrate preparation and Cs interaction.

3. Suppression of high thermionic emission.

4. Study of dielectric substrates.

PART III - MEETINGS, CONFERENCES

On September 20, 1966, H. Timan from Du Mont visited ERDL. On October 11, 1966, H. A. Stahl from ERDL visited the Du Mont Labs. On both occasions, status of the program and future development were discussed with concerned personnel.

TABLE I

ELECTRICAL PROPERTIES OF TUBES PROCESSED DURING THE QUARTERLY PERIOD 8/1 - 10/31/66

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Tube No.	Processing Date	Luminous Sensitivity in μA/L WL	Luminous Sensitivity in μA/L 2540	Thermionic Emission in A/cm² x 10^{12}	Absolute Sensitivity in mA/W 4535Å	6015Å	9000Å	11500Å	Resistance in Ω/□
0-4	8/24/66	56	3.9	.45	3.5	6.7	2.1	.03	3.0×10^{10}
0-10	9/12	27	3.6	37.0	.95	1.7	1.0	.05	1.5×10^{6}
0-12	9/07	22	2.6	7.2	1.0	1.6	1.0	.03	35.0
0-13	9/13	37	4.8	15.0	2.4	2.9	1.7	.15	1.0×10^{6}
0-14	9/09	26	3.6	26.0	1.8	1.9	1.1	.12	2.0×10^{6}
0-16	9/13	19	2.6	3.1	1.9	1.9	1.1	.12	32.0
0-17	9/14	32	4.1	13.0	1.7	2.5	1.4	.11	6.0×10^{3}
0-19	9/15	36	4.2	17.0	2.4	2.9	1.6	.15	4.0×10^{5}
0-20	9/21	45	7.3	23.0	2.4	2.6	2.3	.15	500.0
0-22	9/22	44	5.2	15.0	2.1	3.6	2.2	.07	5.5×10^{9}
0-30 (Leaker)	9/28	51	4.3	--	-	-	-	-	---
0-31	9/29	65	7.8	30.0	3.3	5.0	2.9	.12	4.3×10^{10}
0-32	9/28	40	3.3	3.6	3.3	3.5	1.9	.05	$> 10^{12}$
0-36	10/03	59	5.9	.36	3.8	5.3	3.0	.05	1.5×10^{5}
0-37	10/06	32	2.3	1.9	1.5	3.0	1.8	.02	4.3×10^{10}
0-41	10/12	40	6.1	16.0	1.5	2.6	2.4	.16	1.5×10^{6}
0-44	10/13	38	4.4	34.0	1.5	2.9	1.8	.08	5.5×10^{6}
0-46	10/14	46	7.5	31.0	2.5	3.3	3.3	.26	3.0×10^{7}
0-47	10/14	38	7.0	9.6	2.3	3.1	3.3	.47!	5.0×10^{6}
0-49	10/18	42	3.4	11.0	2.4	4.2	2.2	.03	7.5×10^{7}
0-50	10/19	42	5.7	15.0	1.8	2.9	3.1	.12	2.4×10^{3}
0-51	10/19	60	6.5	3.2	2.5	4.3	3.6	.06	6.7×10^{10}
0-55 (Leaker)	10/22	56	6.2	--	-	-	-	-	---
0-56	10/27	52	9.4	13.0	2.5	3.6	3.8	.44!	4.6×10^{6}
0-57	10/26	37	4.4	49.0	2.9	3.8	1.7	.14	3.0×10^{8}

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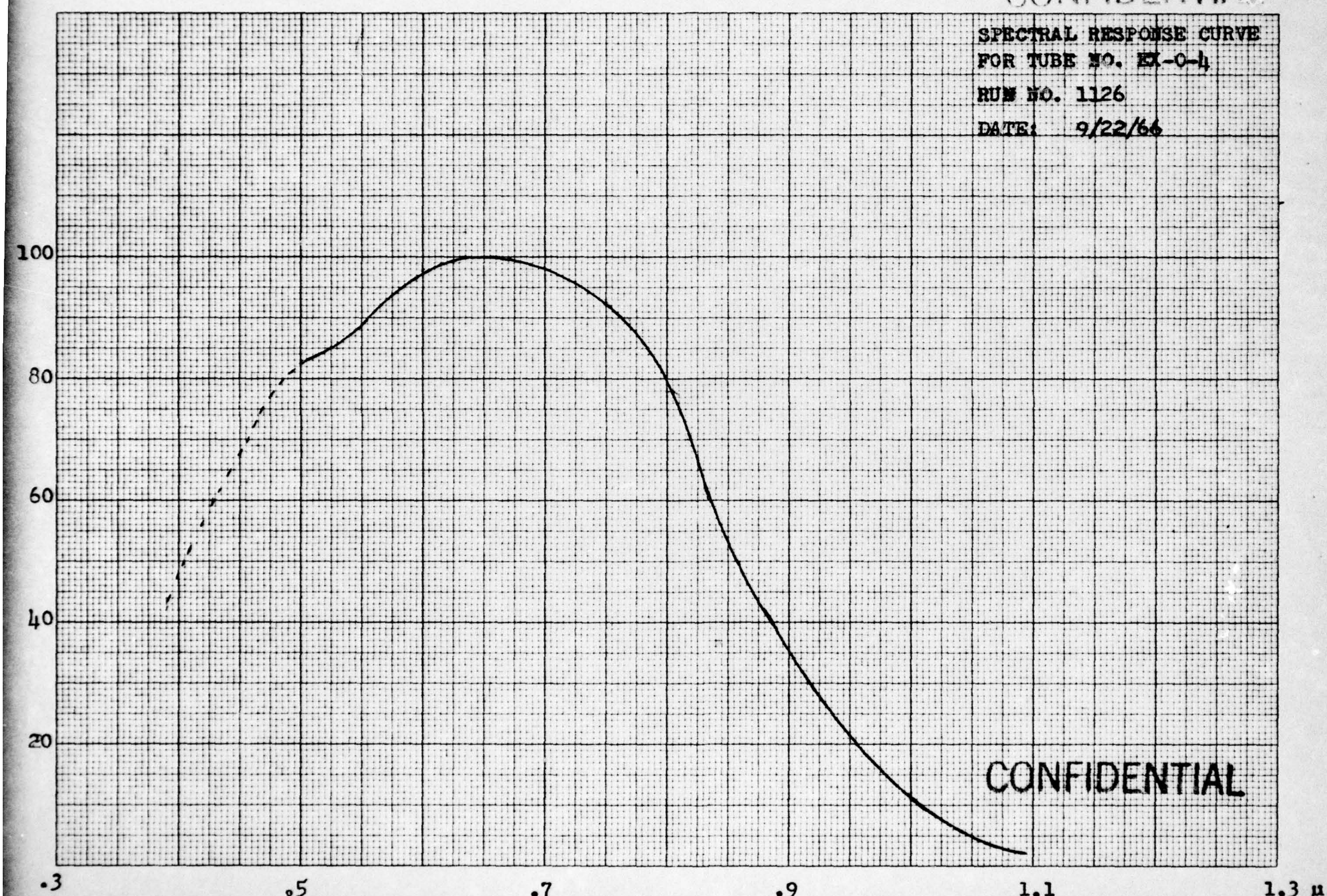
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DATE: 9/22/66
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80
60
40
20
.3
.5
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.9
1.1
1.3 µ
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FIGURE NO. 1

NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

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MADE IN U. S. A.

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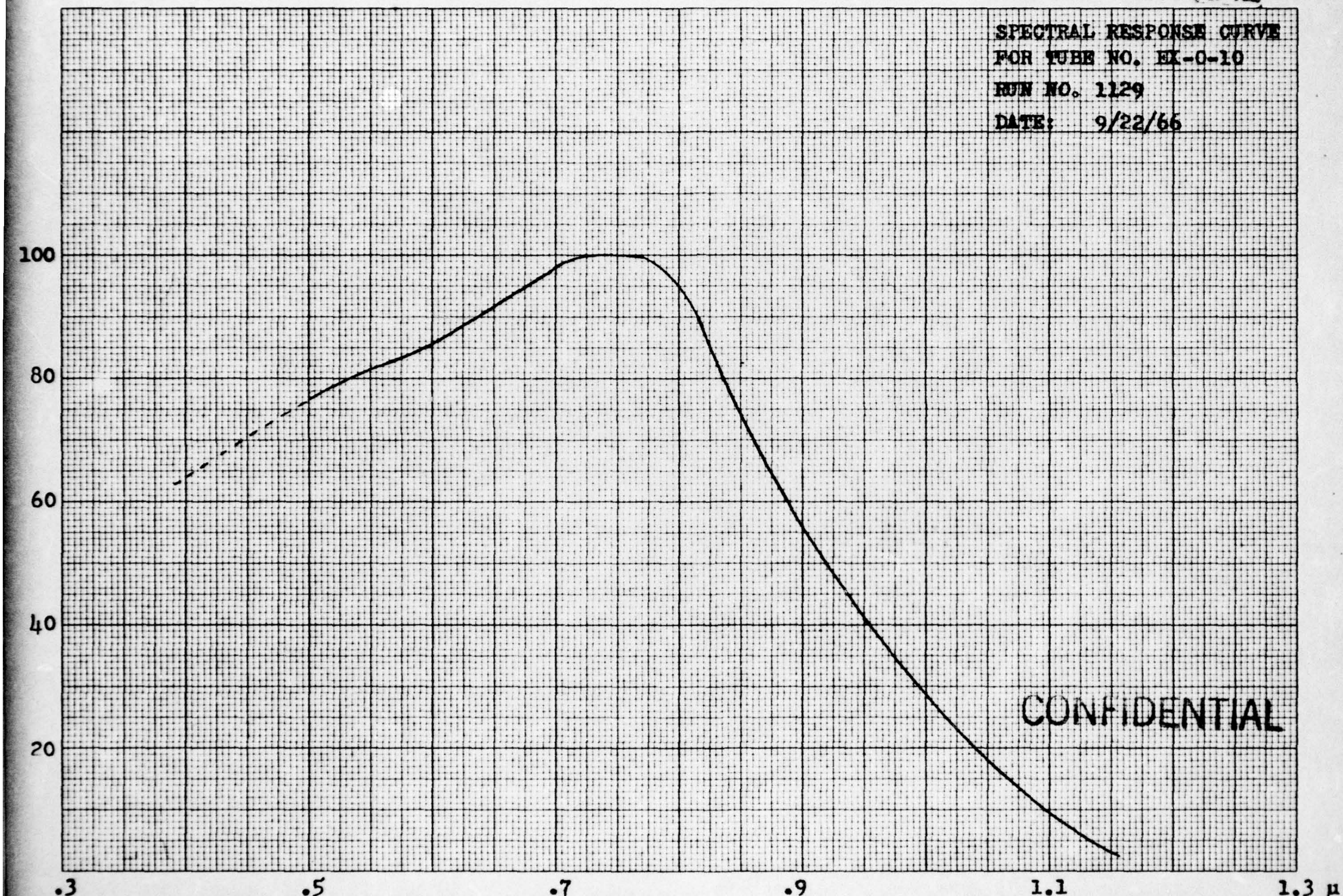

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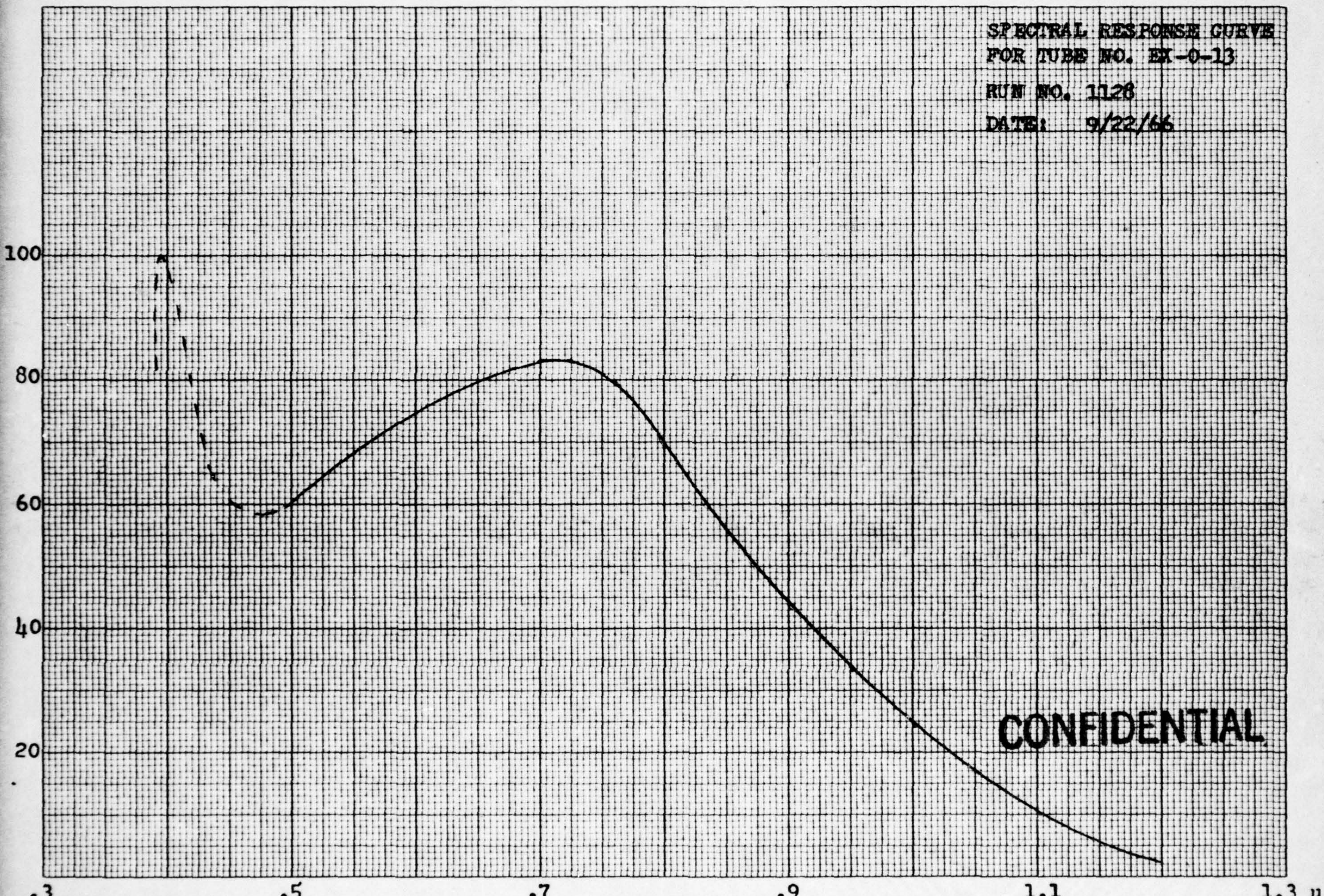

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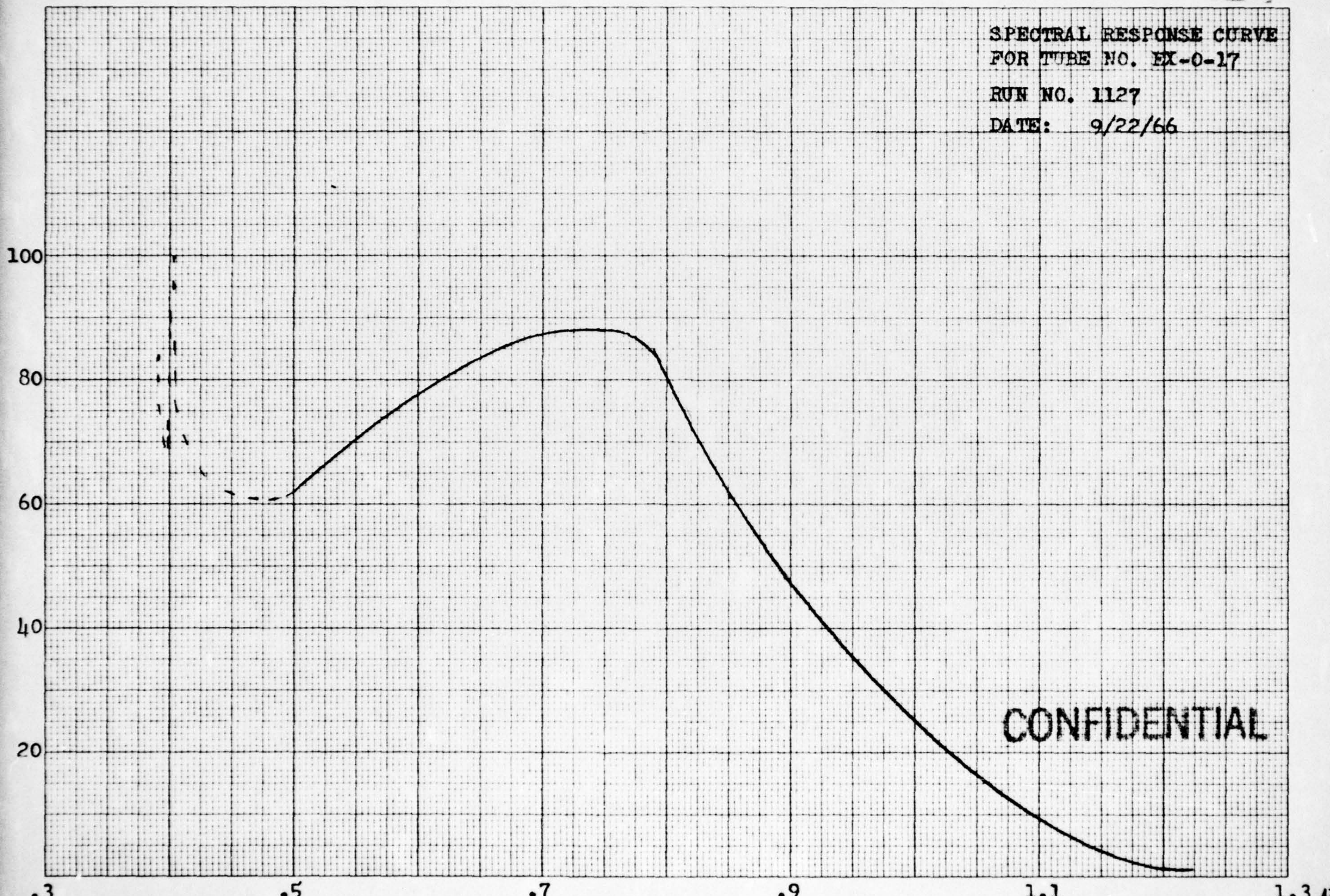
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FOR TUBE NO. EX-0-17
RUN NO. 1127
DATE: 9/22/66
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80
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.3
.5
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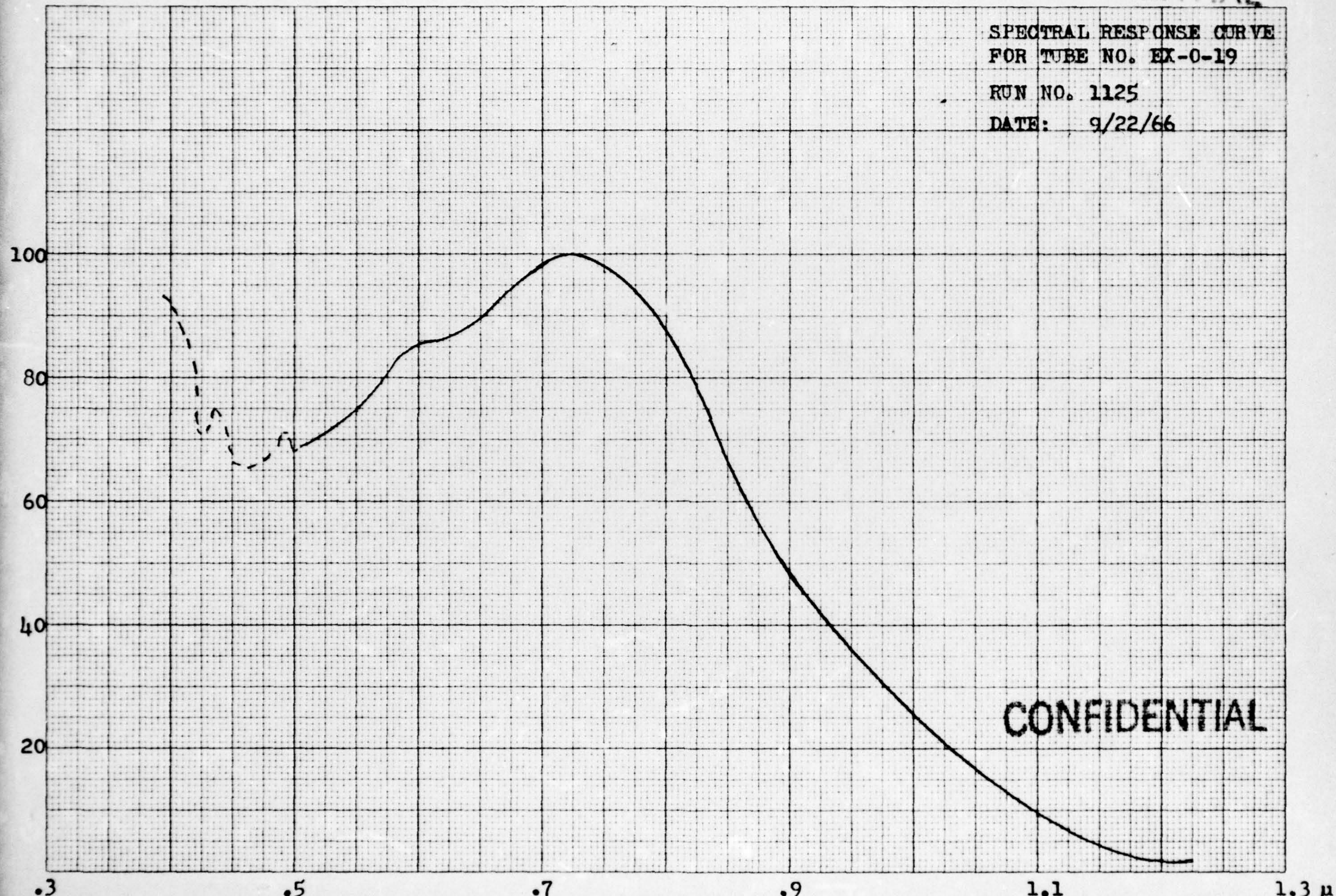
.9
1.1
1.3 μ

FIGURE NO. 4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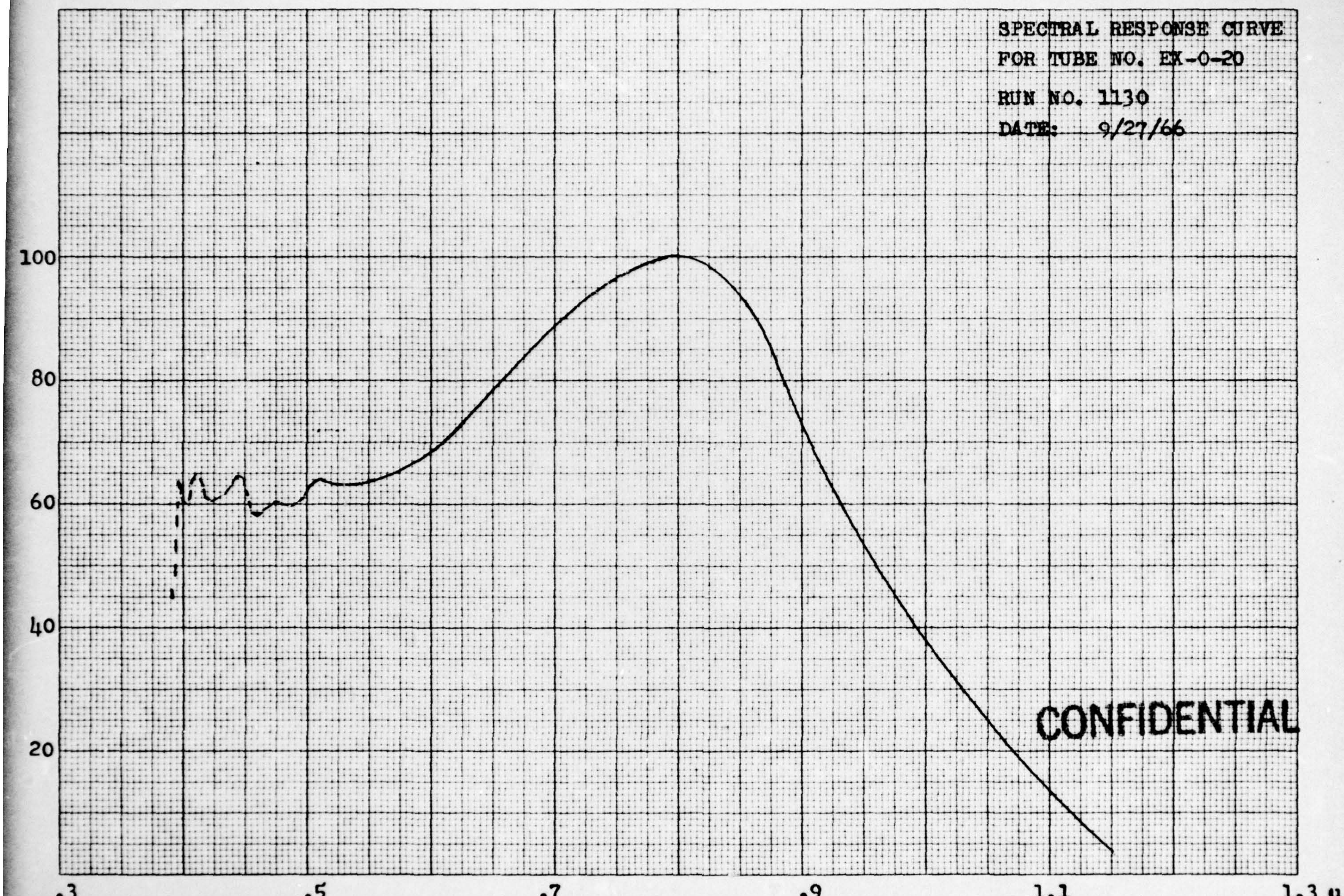
.5
.7
.9
1.1
1.3 μ

FIGURE NO. 5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40
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.5
.7
.9
1.1
1.3 µ

FIGURE NO. 6

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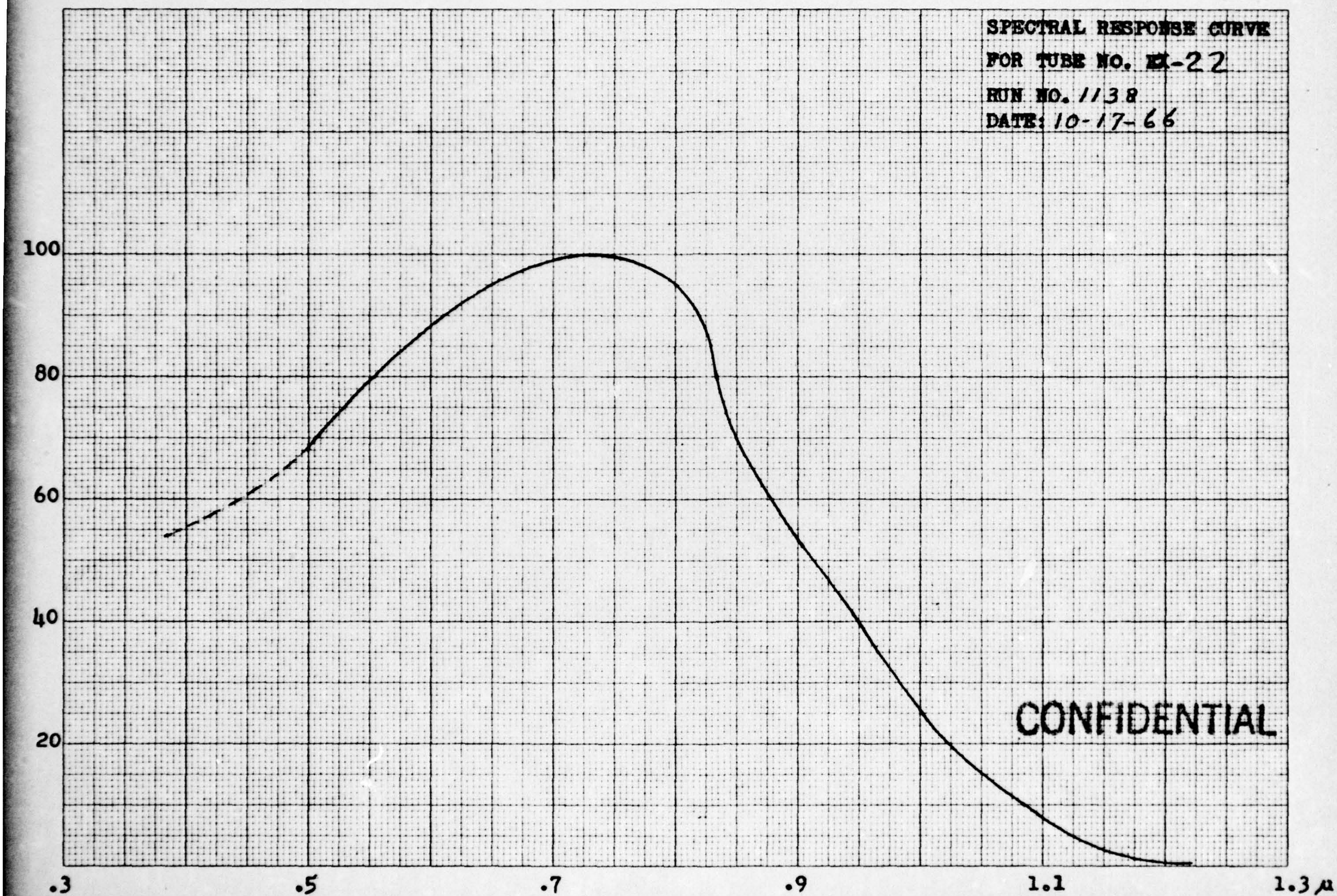

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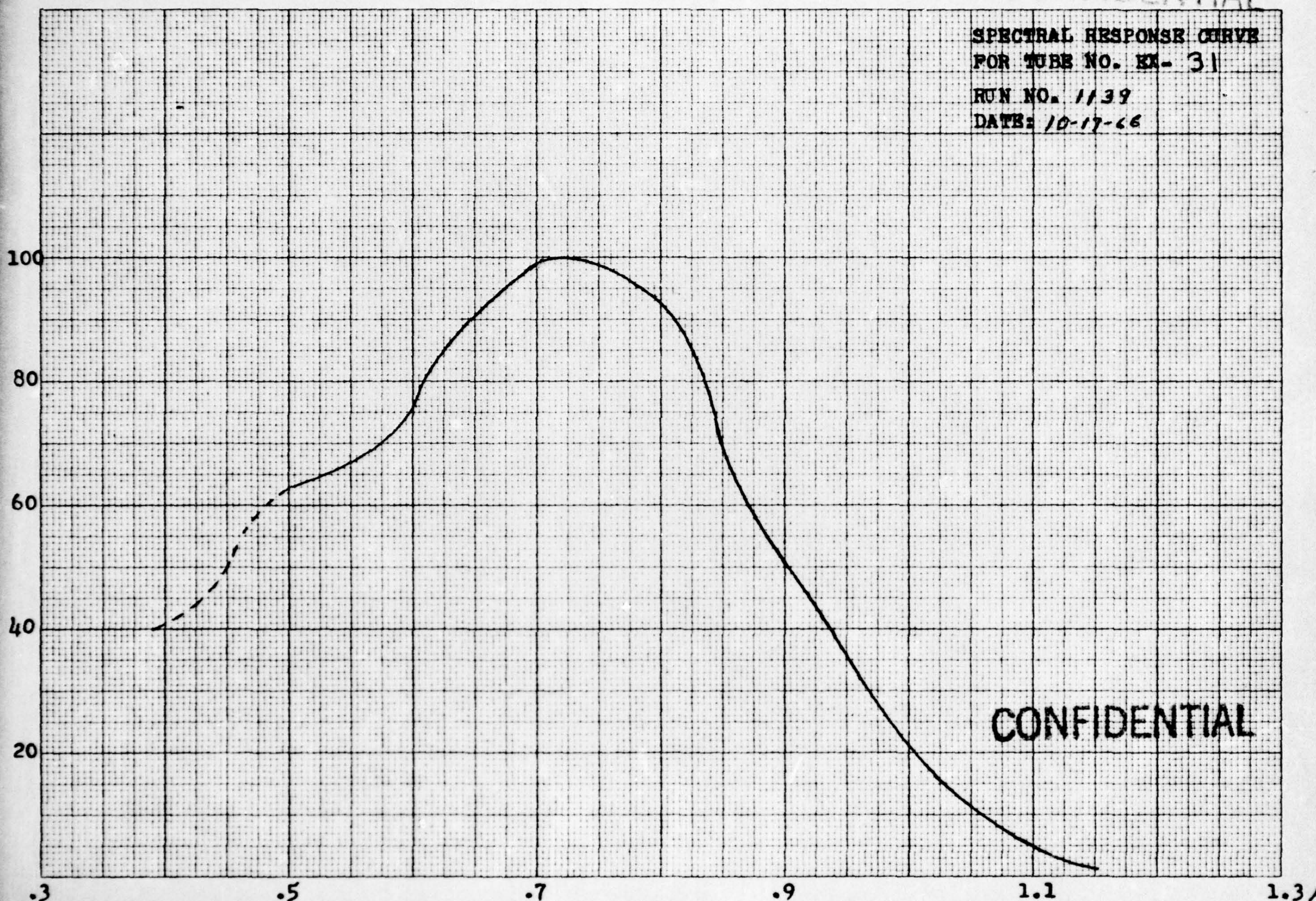
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40
20
.3
.5
.7
.9
1.1
1.3 μ
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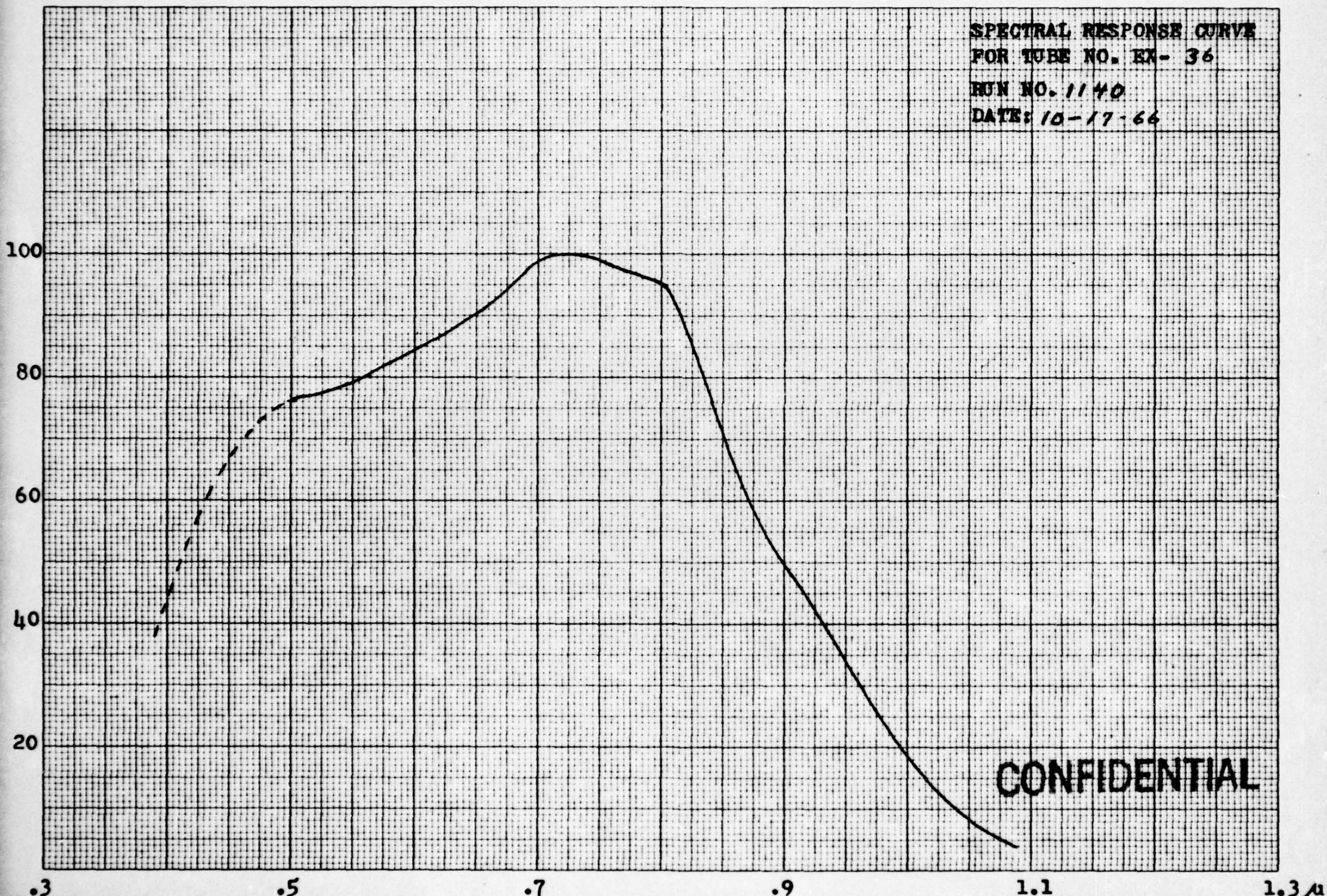
FIGURE NO. 8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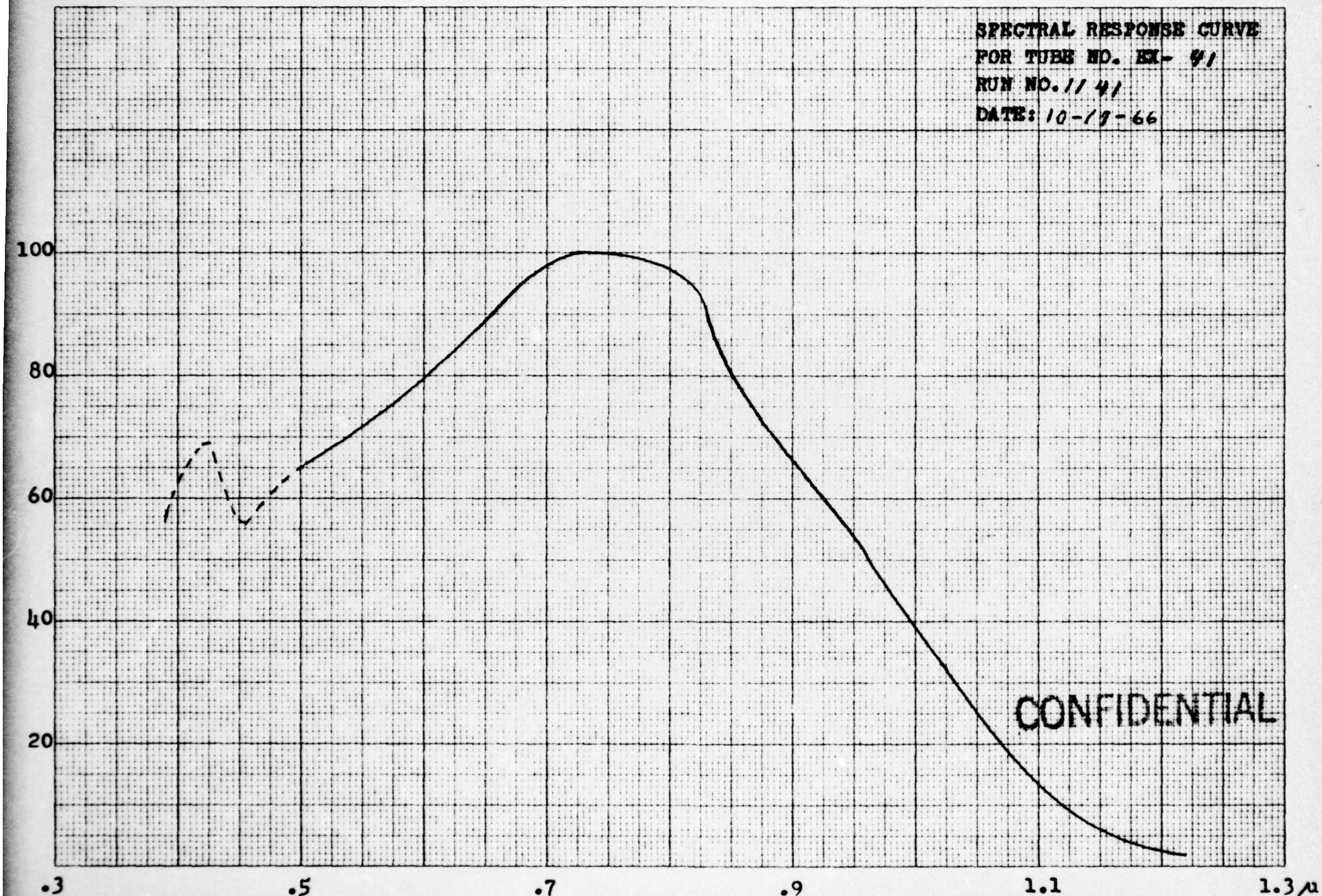
.9
1.1
1.3 µ

FIGURE NO. 9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FOR TUBE NO. EX- 41
RUN NO. 11 41
DATE: 10-17-66
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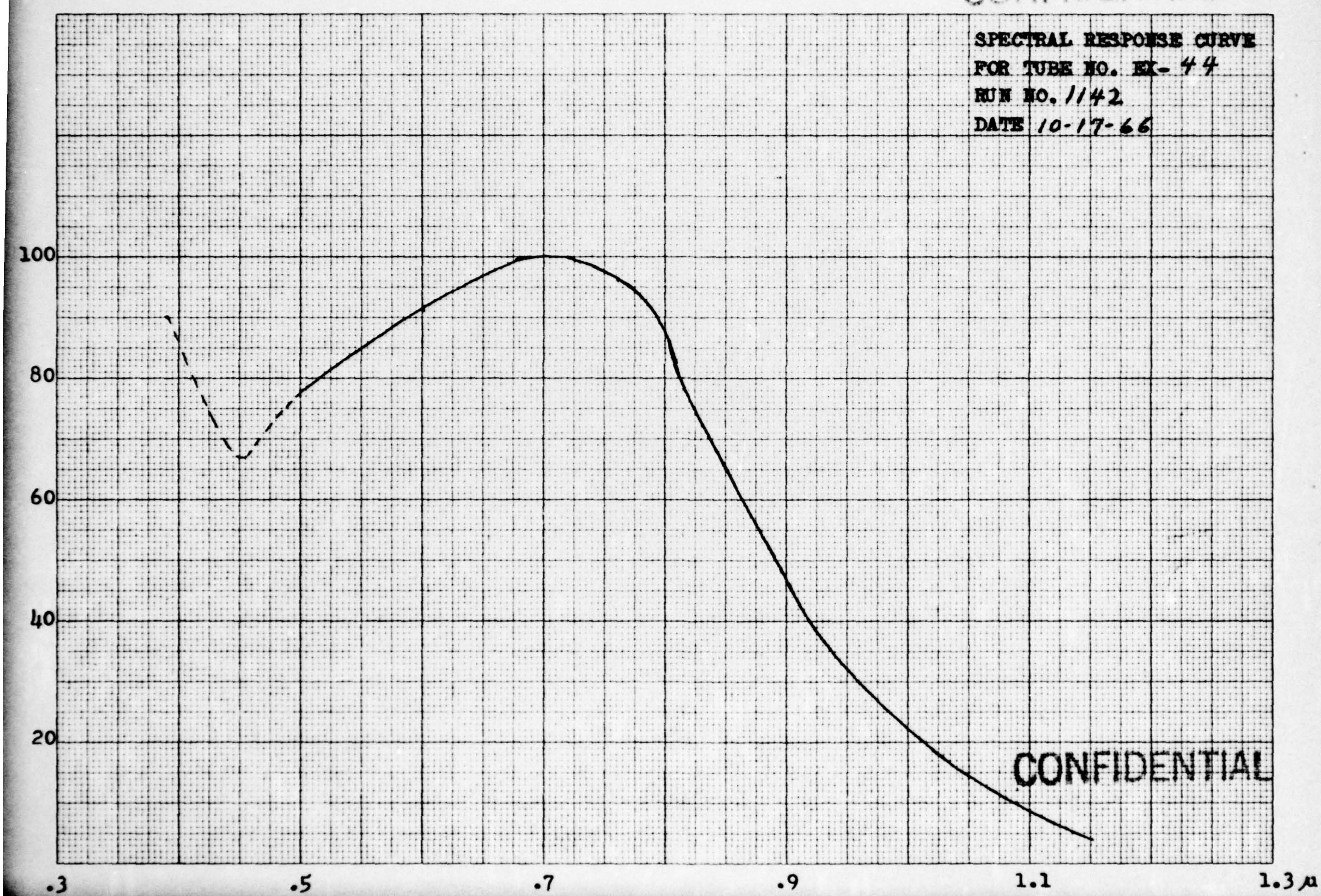
80
60
40
20
.3
.5
.7
.9
1.1
1.3μ

FIGURE NO. 10

NO. 340R-20 DIETZGEN GRAPH PAPER
20 X 20 PER INCH

EUGENE DIETZGEN CO.
MADE IN U. S. A.

CONFIDENTIAL



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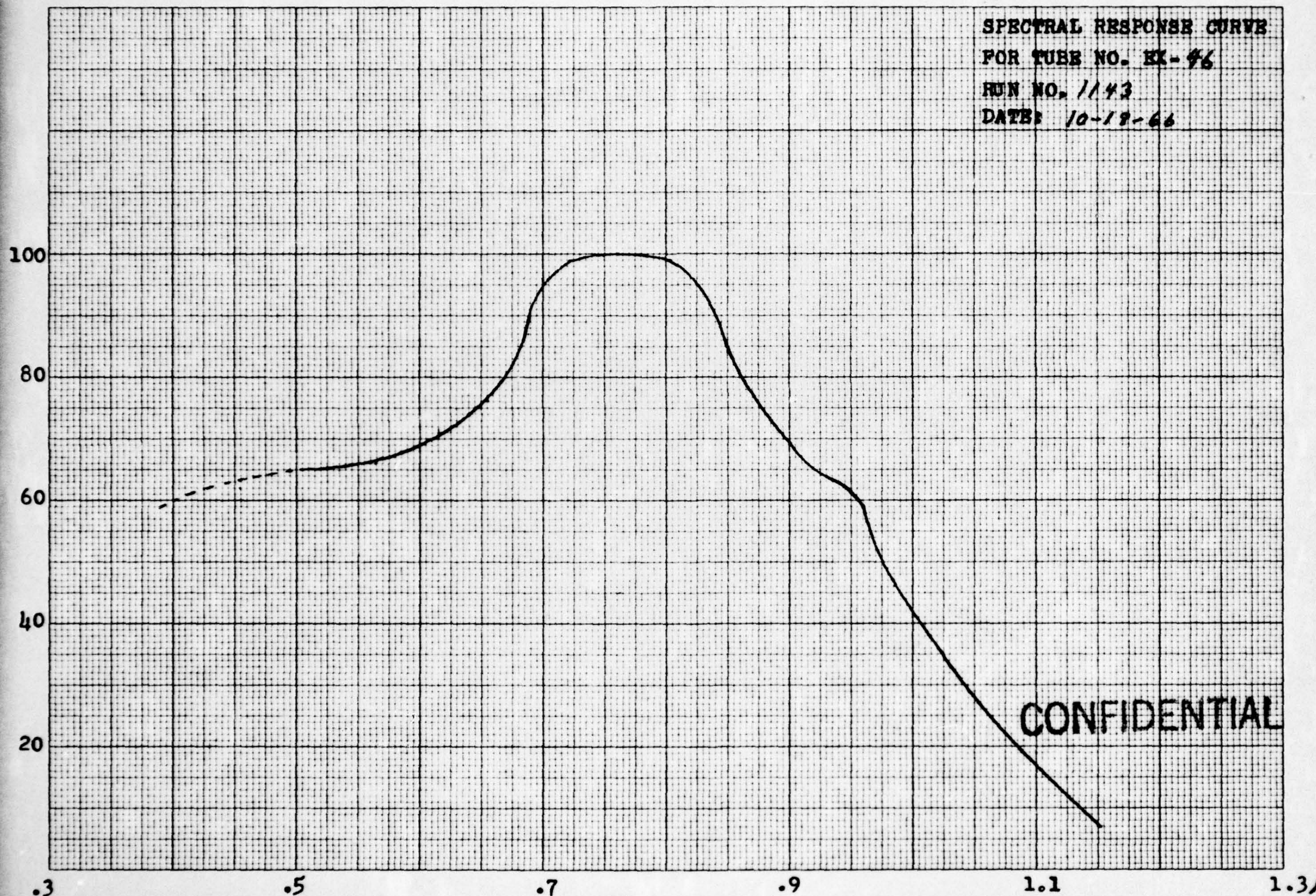
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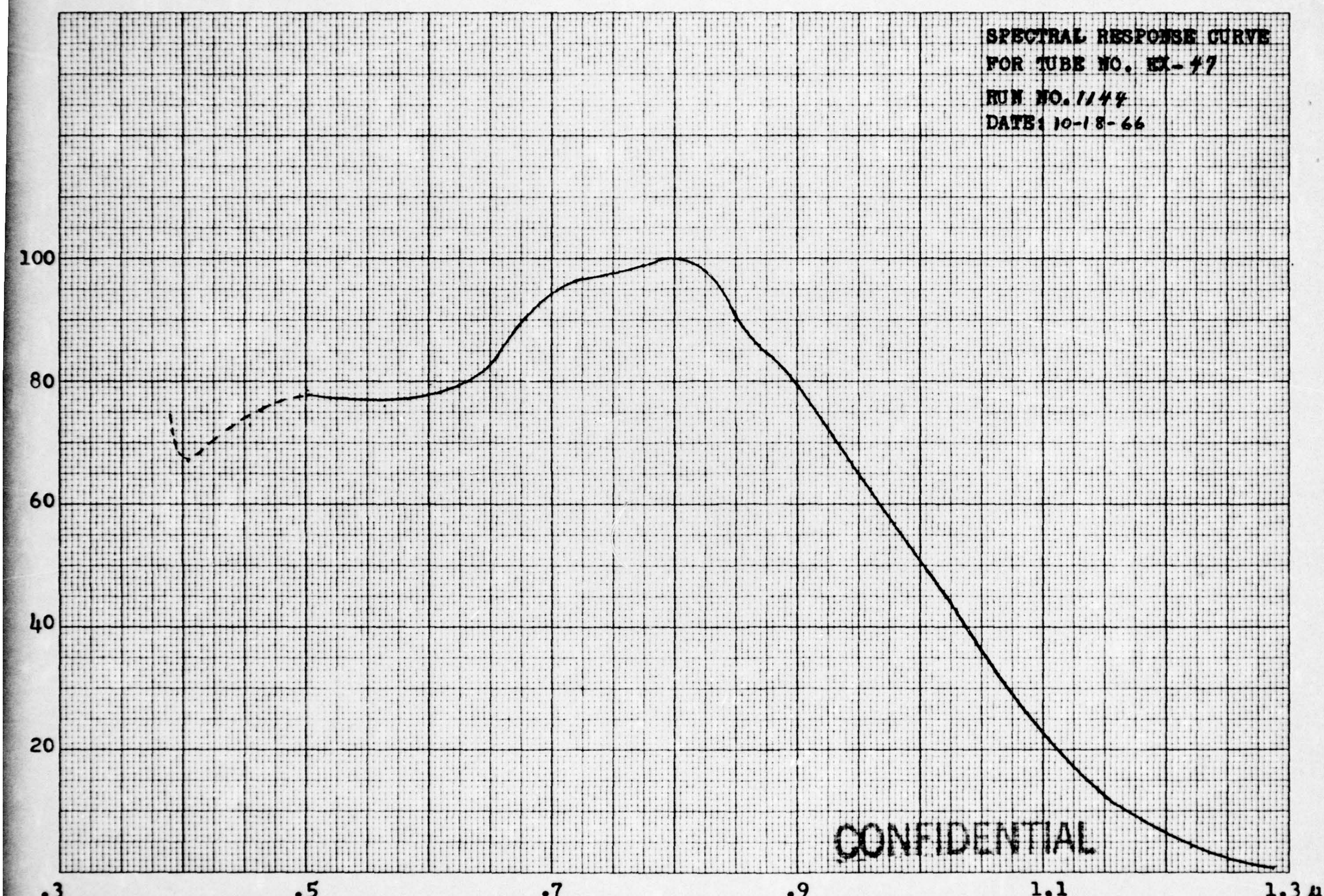
.7
.9
1.1
1.3μ

FIGURE NO. 12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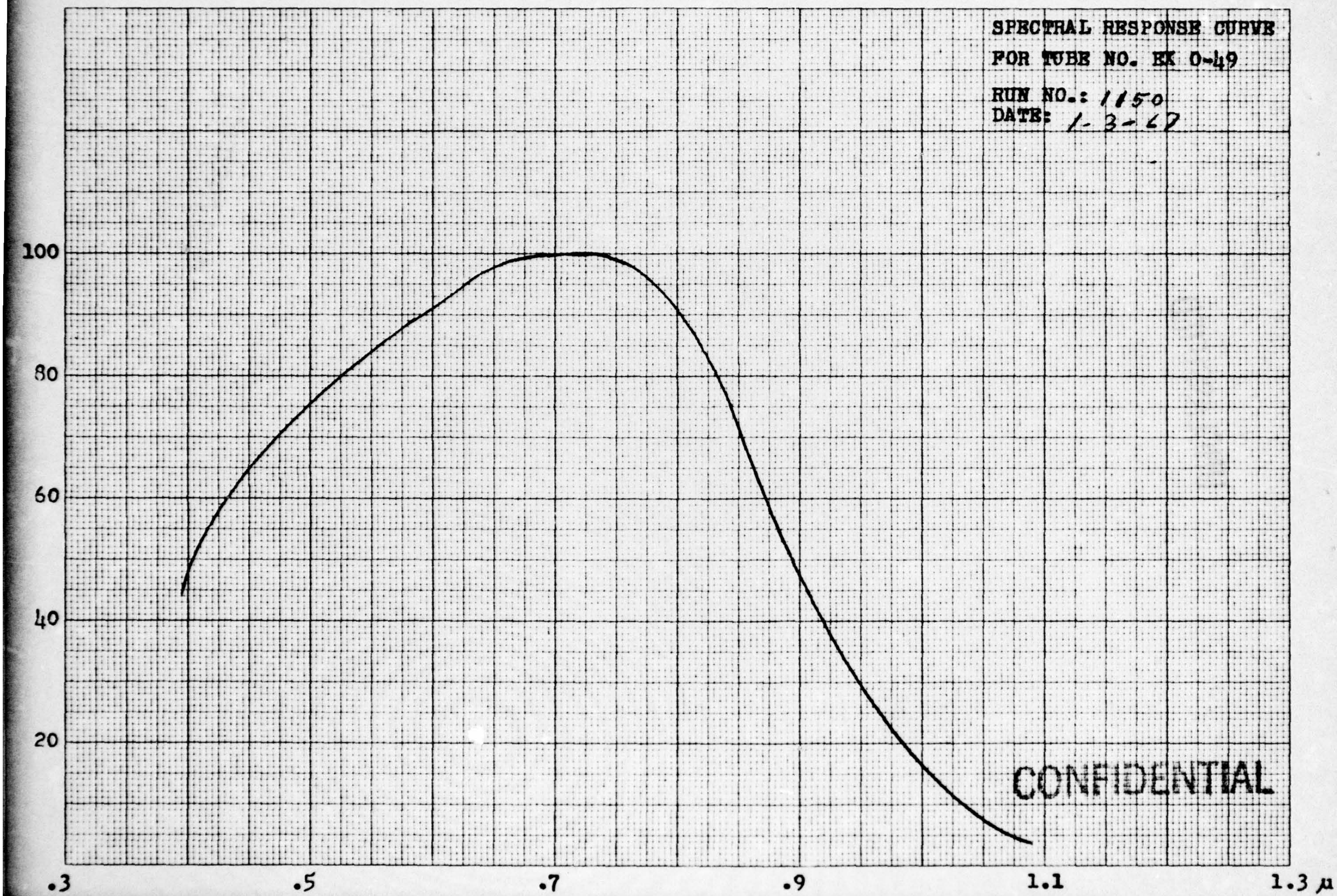
.7
.9
1.1
1.3 µ

FIGURE NO. 13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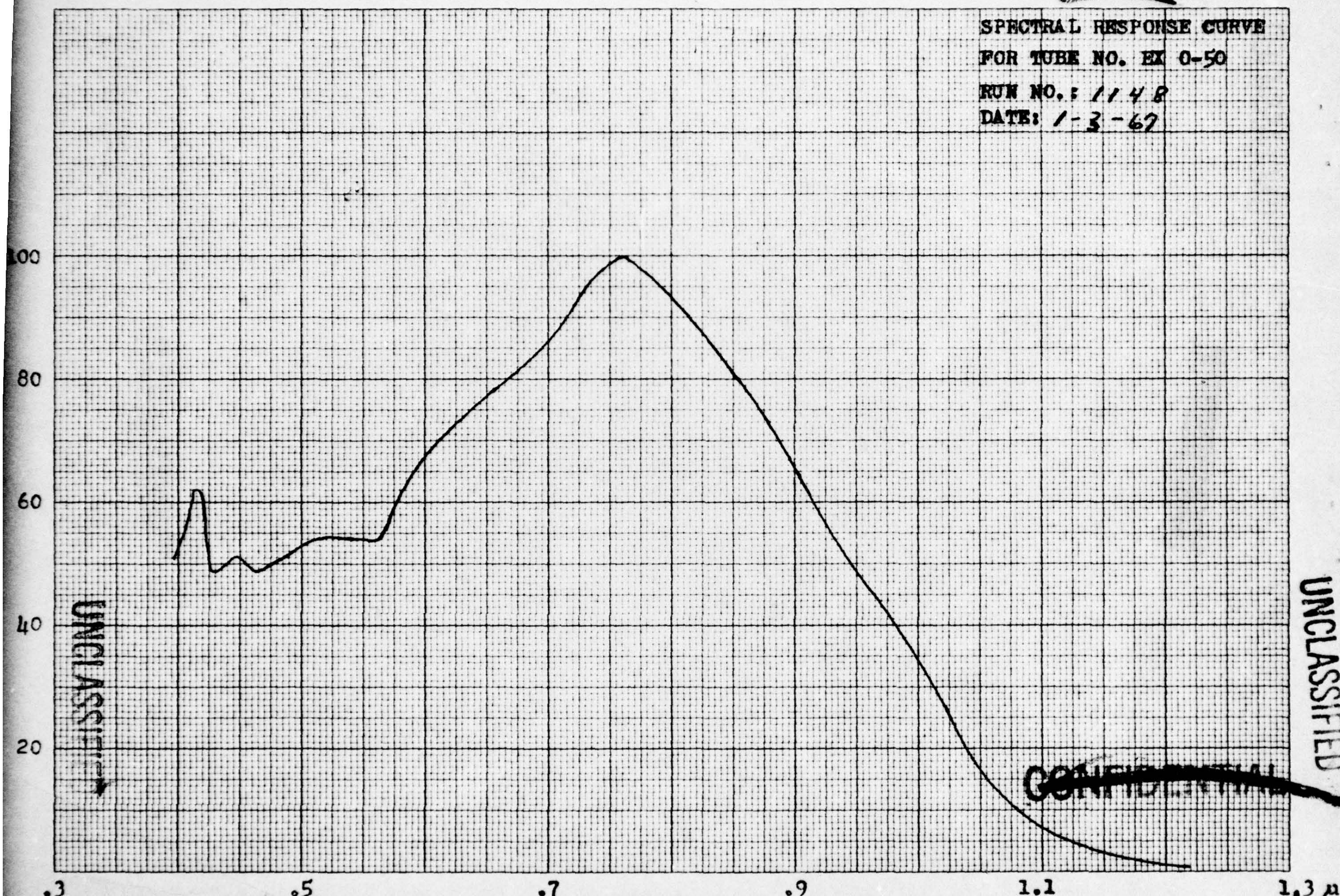
.7
.9
1.1
1.3 μ

FIGURE NO. 14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40
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.3
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.7
.9
1.1
1.3 μ

FIGURE NO. 15